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The Effect of Time Advance Mechanism (TAM) in Modeling and Simulation: DES & DTS Comparison Analysis, Case Study: Combat Simulation

The Effect of Time Advance Mechanism (TAM) in Modeling and Simulation: DES & DTS Comparison Analysis

Case Study: Combat Simulation

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Outline

- **Motivations and Concepts**
- **Emergent Effects of TAMs**

  Skipping Phenomenon

  – Scenario 1: Simple Agent Engagement

  – Scenario 2: The Littoral Combat Ship (LCS) Battle

- **Conclusion**

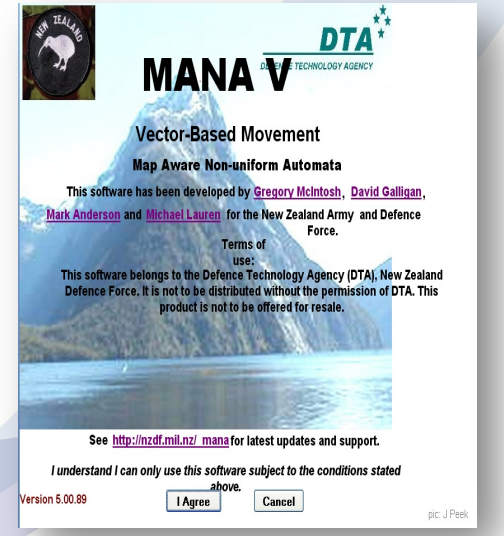
Motivations and Concepts

"All models are wrong, but some are useful." (Box 1979)

…but how wrong can a model be before its not useful?

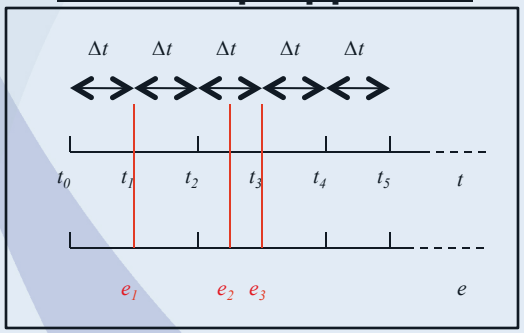
- The effects of TAM are not well understood.
- The effects of Δt are not well described in the literature.
- What are the limitations and strengths of each mechanism?

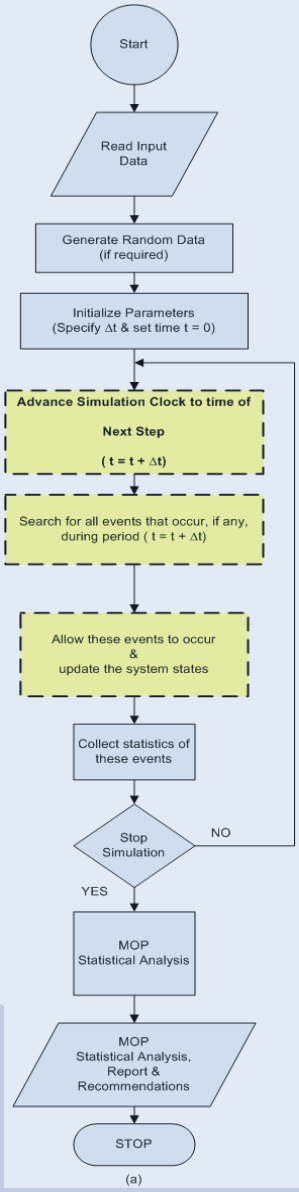
Discrete Event Simulation (DES) and Discrete Time Simulation (DTS)



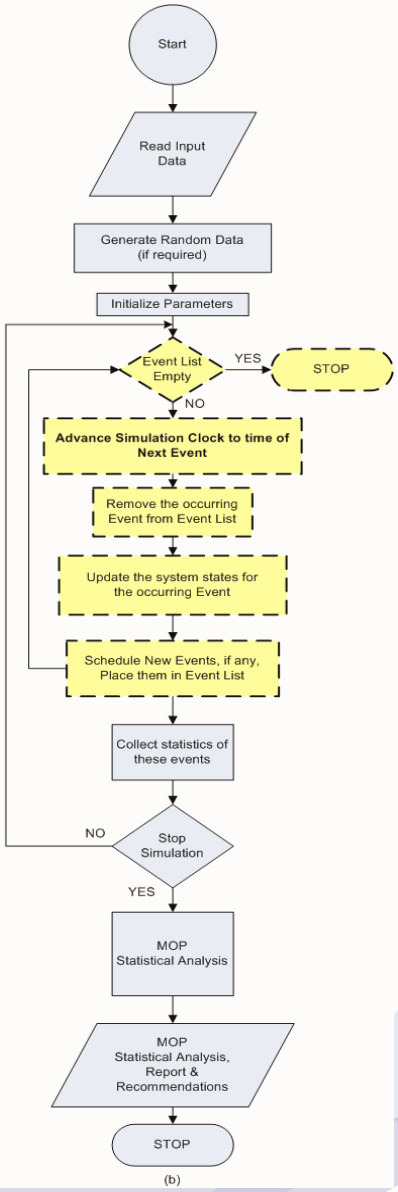
Discrete Time Simulation (DTS)

Time-Step Approach

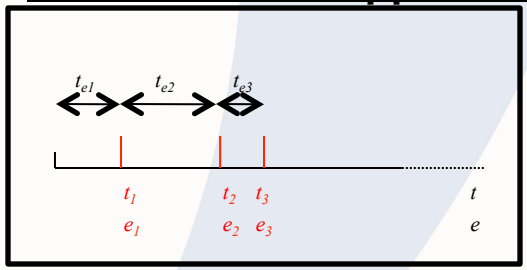




Discrete Event Simulation (DES)

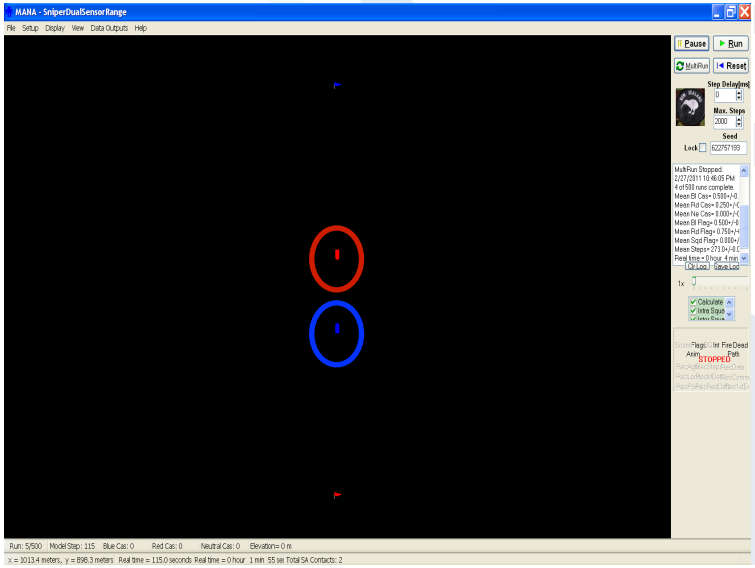


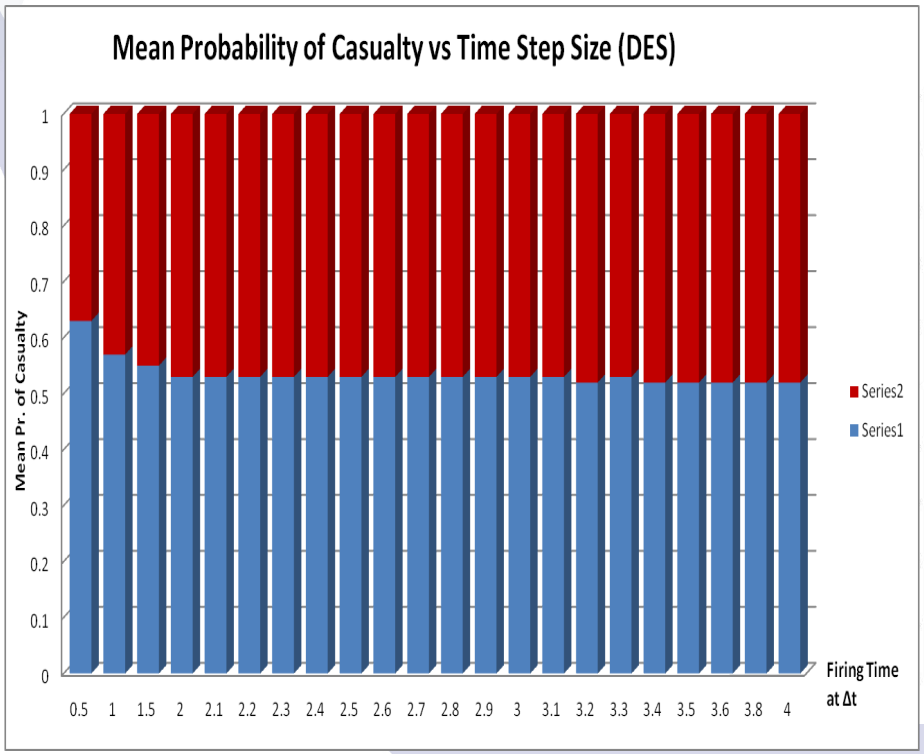
Discrete Event Approach

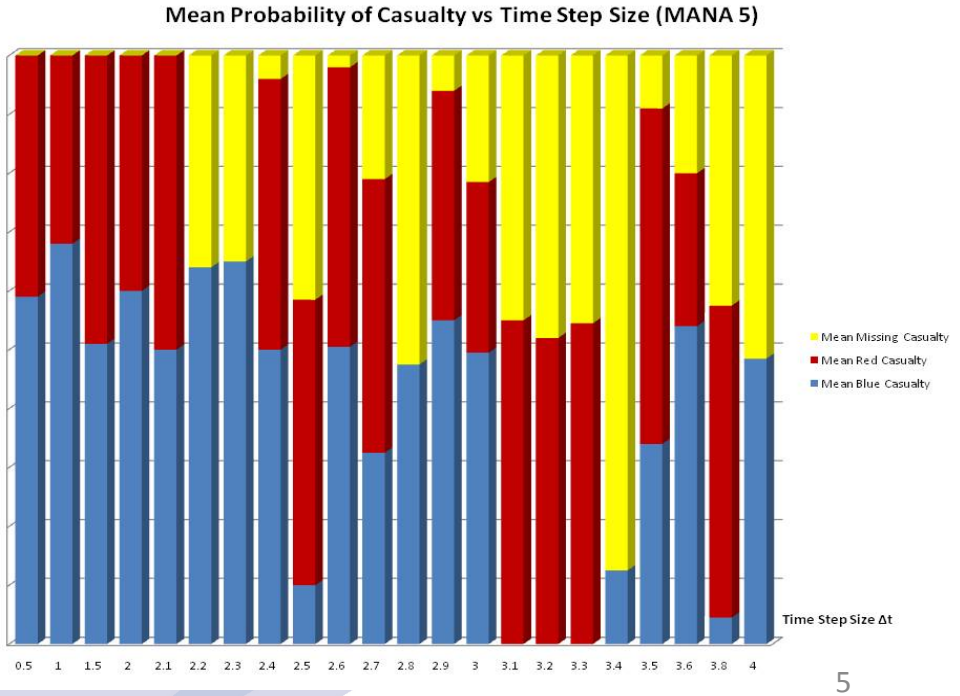


S 1.1: Simple Agent Engagement

Parameters	Red Agent	Blue Agent
Speed	15	10
Sensor Type	Cookie-Cutter	Cookie-Cutter
Sensor Range	17	13
Weapon Range	17	13
P_{kill}	1	1
MOE	Mean Casualty Percentage at 200 replications	







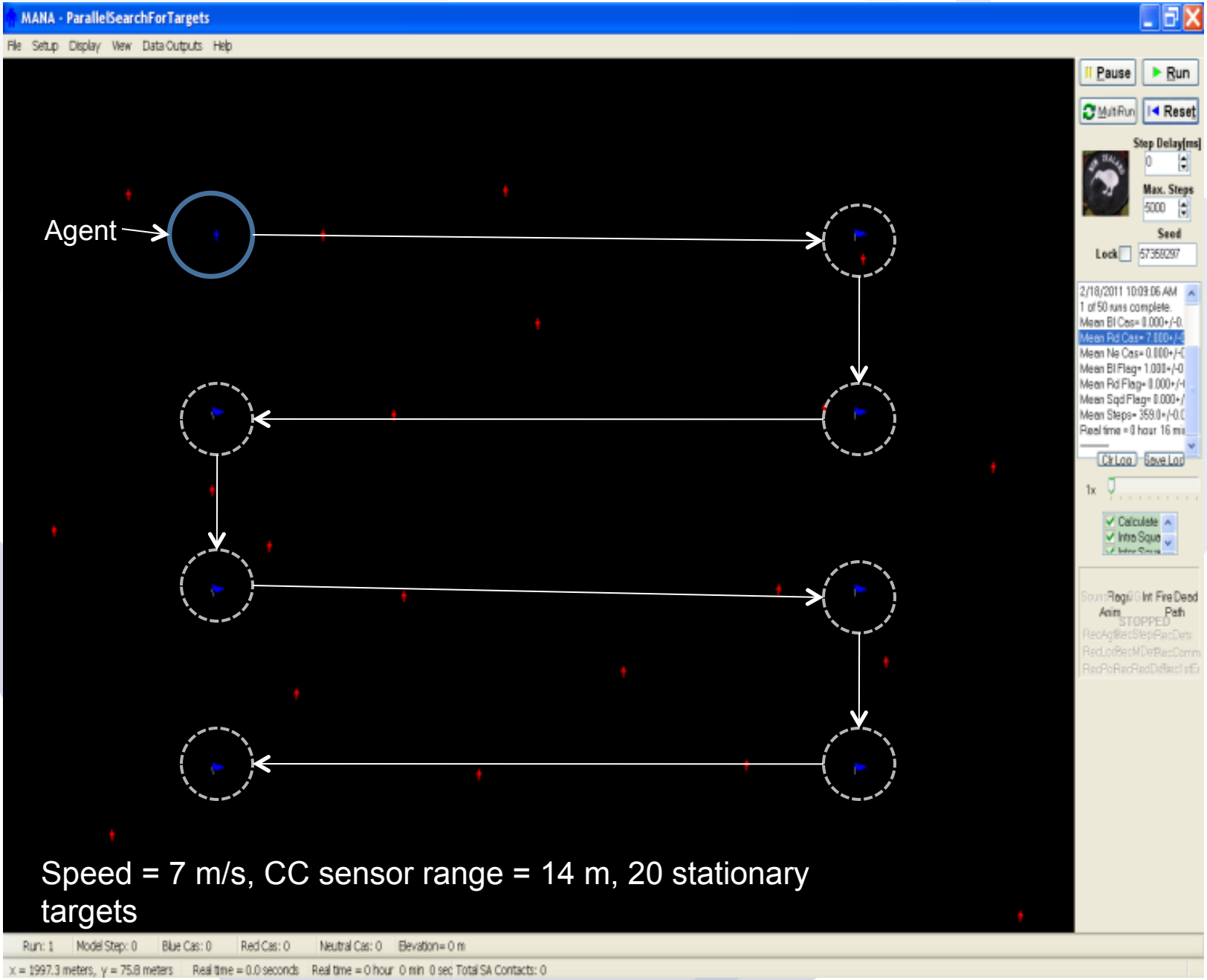
Single moving searcher looking for stationary targets.

Searcher:
speed: constant @ 7m/s
sensor type: cookie cutter
sensor range: 14m

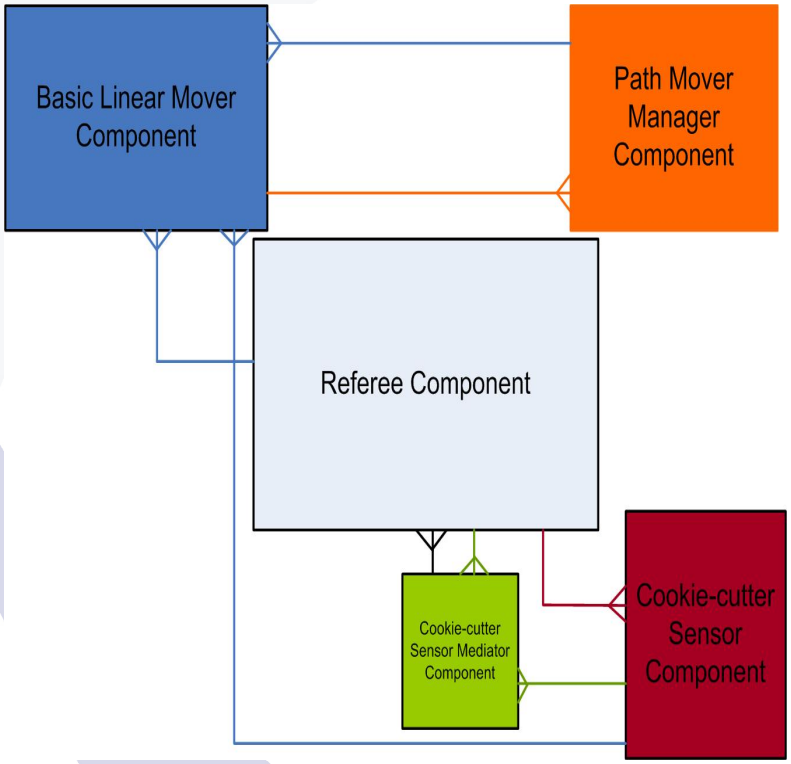
Targets: 20
distribution: randomly over combat area
search pattern: Parallel (Washburn 2009)

Set-up:
Grid: 2000 x 2000 m
Replications: 200
Measure: number of detected targets

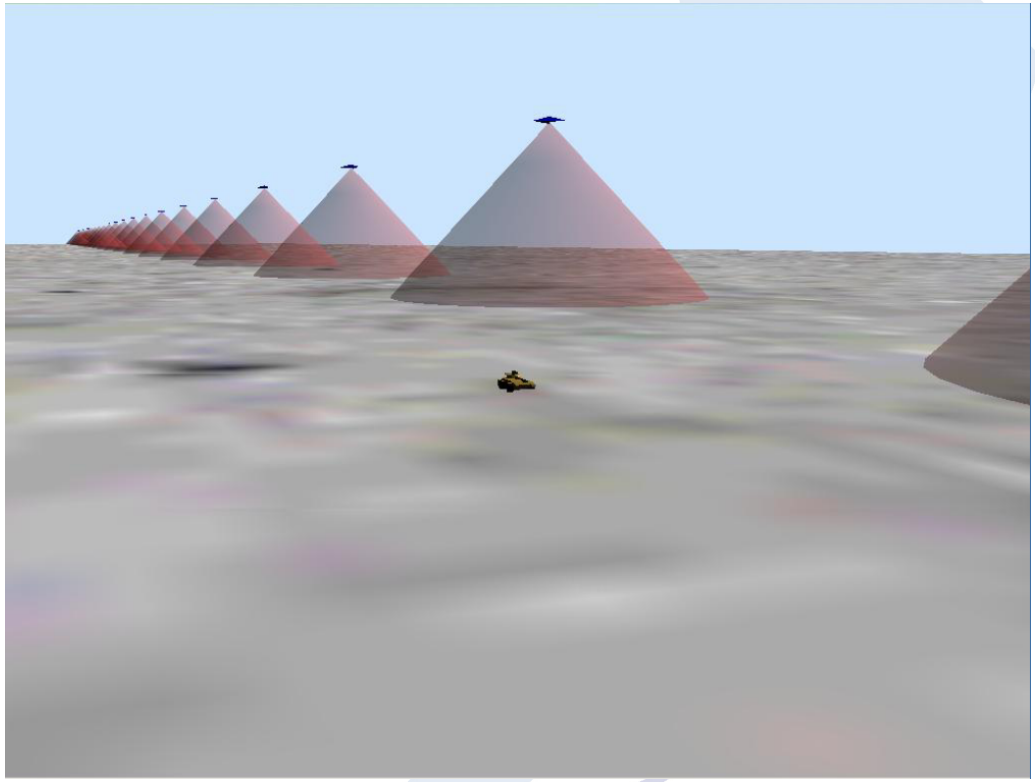
S1.2 Simple Search & Detection Operation



S1.2 Simple Search & Detection Operation



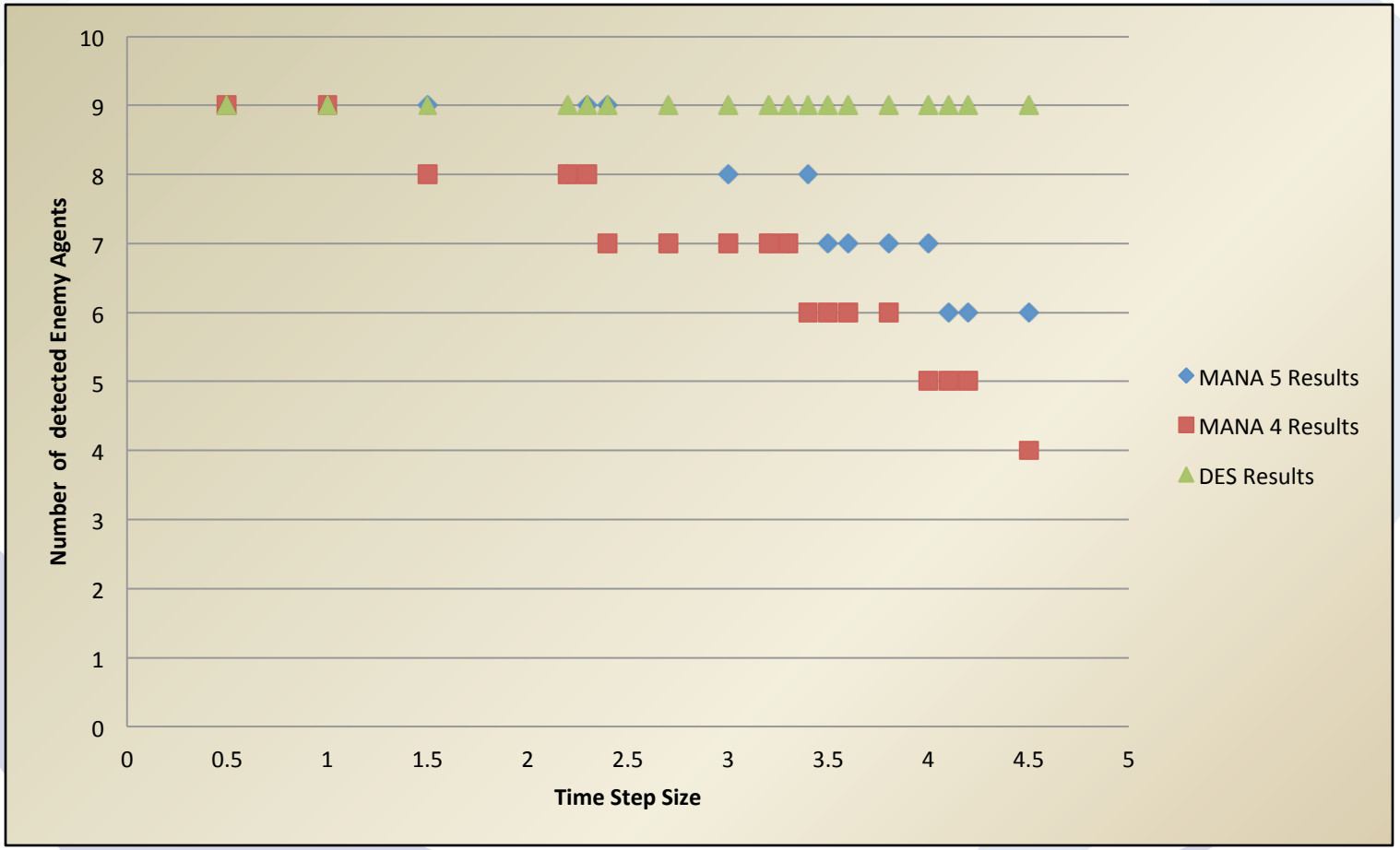
Sensor agent event graph modeled in DES



3D View from MARSS (Dickie 2002)

S 1.2: Results and Observations

- 200 replications were conducted in MANA 5 and Simkit.



- How to ensure this phenomenon is detected in complex simulations, or it is not affecting non-visible variables?

S 2: The LCS Battle

- Original scenario is the work of an NPS Master Thesis (*Jacobson 2010*).
- **Elements:**
  1) 1 LCS equipped with 2 types of missiles:
     a- NLOS b- Harpoon
  2) 1 Helicopter/UAV equipped with 4 types of missiles: a- Hellfire b- LOGIR c- APKWS d- DAGR
  3) 20 enemy boats equipped with only one missile type: C-802

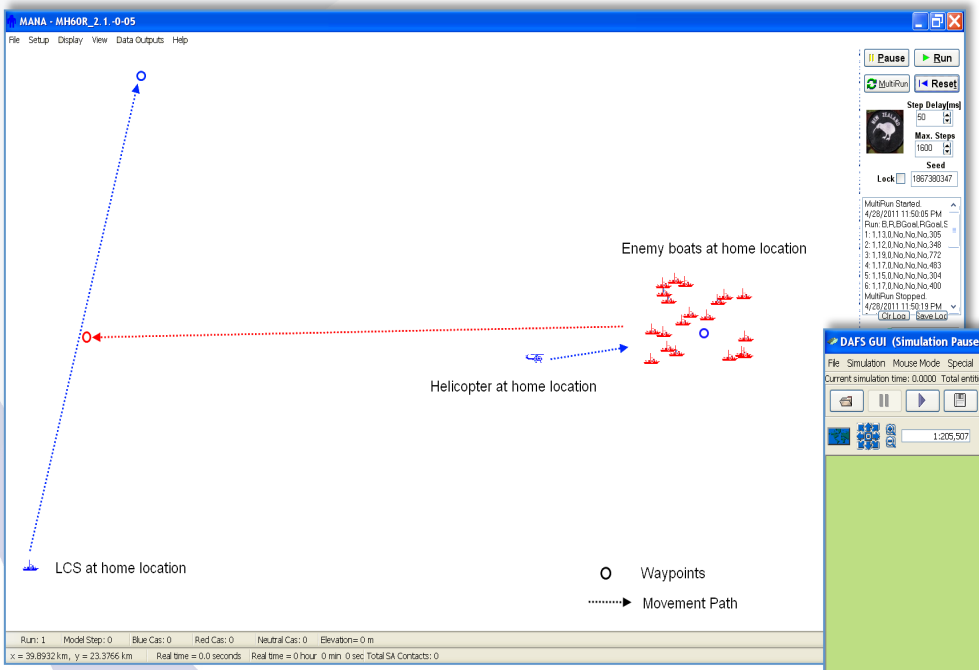
(Naval Warfare Development Command 2007)

- **Purpose:** investigate different weapons on the effectiveness of the LCS and Helicopter to neutralize enemy boats and essential engagement factors.

- **Original Study Results**: Firing rate is the most important factor, LSC missiles and capability need to be enhanced

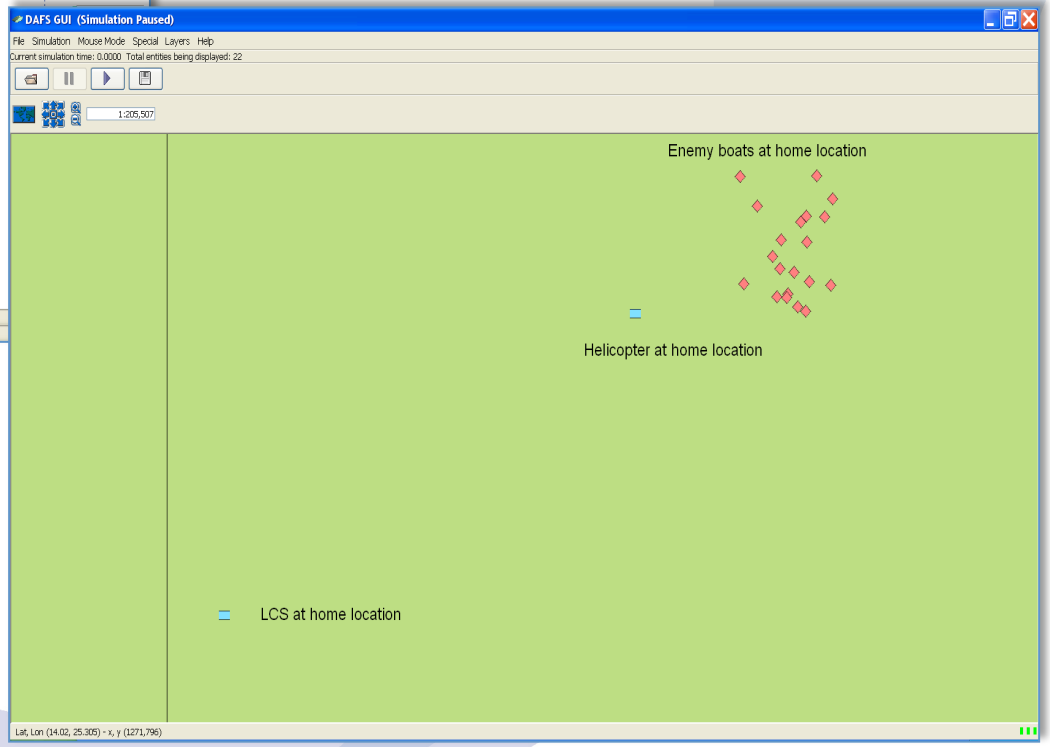
S 2: The LCS Battle

Our Study: Investigate the impact of TAM on the scenario results by comparing DES and DTS results.



LCS scenario in MANA 5 environment
Discrete Time Simulation (DTS)

LCS scenario in DAFS environment
Discrete Event Simulation (DES)



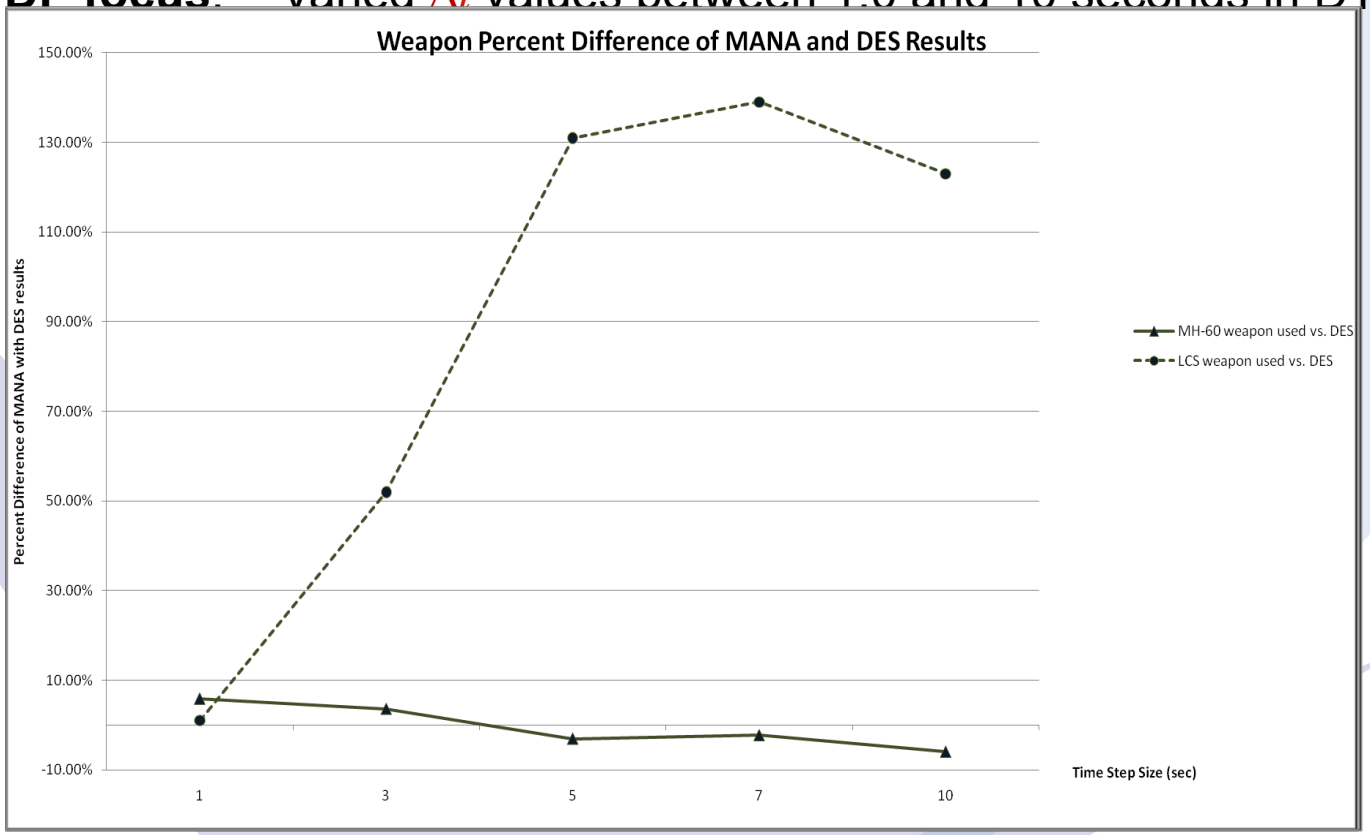
S 2: The LCS Battle

Results:

- Original study run 512 Design Points (DP) with 40 replications at Δt = **10** seconds.
- We found that more than 81 DPs can have significant change in outcome.
- **MOE**: 1. Number of kills (LCS and Enemy)

  2. Number of weapons fired (LSC and Helicopter)

- **One DP focus**: - Varied Δt values between 1.0 and 10 seconds in DTS



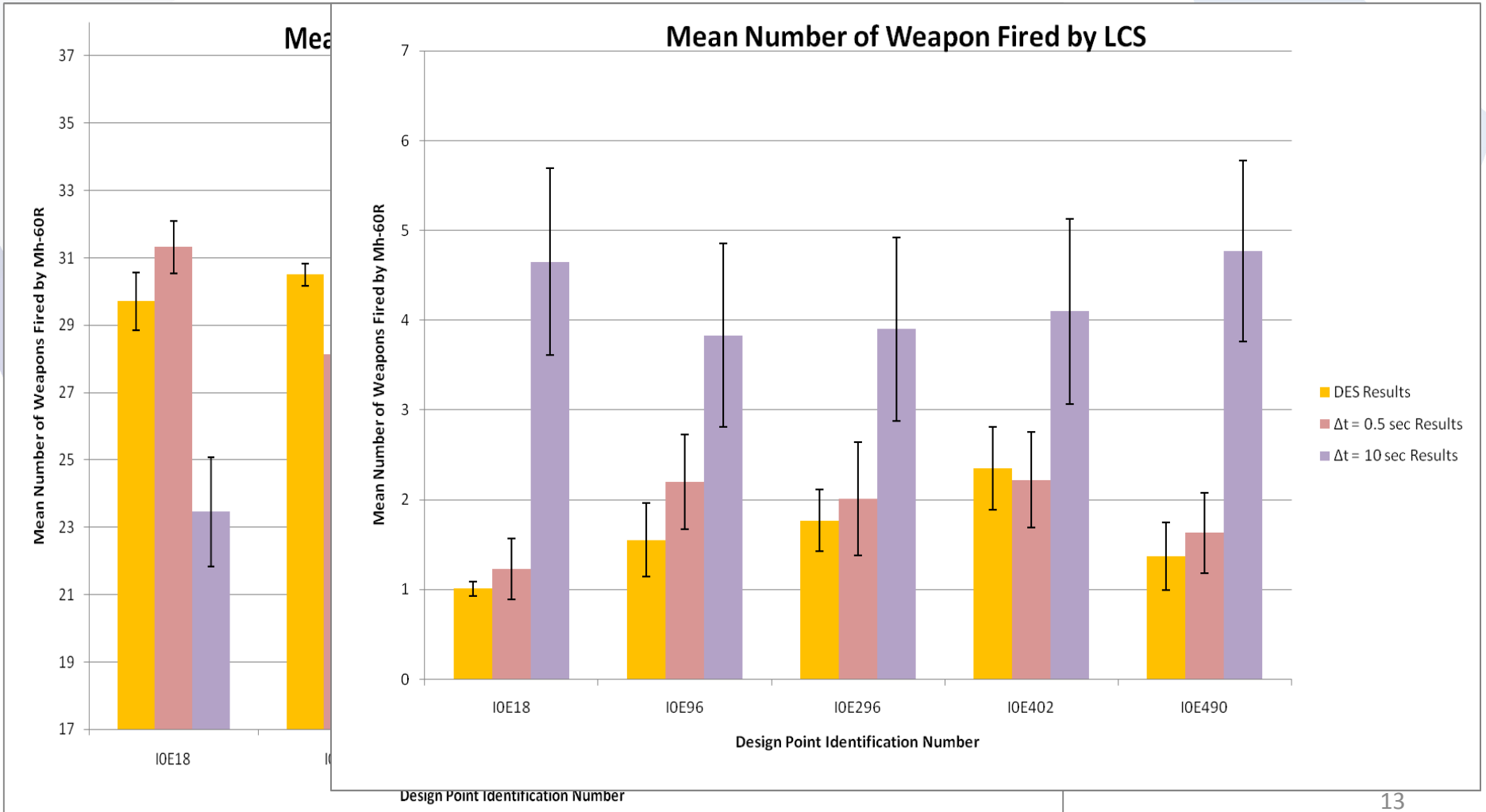
S 2: The LCS Battle

Results (cont…)

- Five DPs were tested in details for greater coverage.

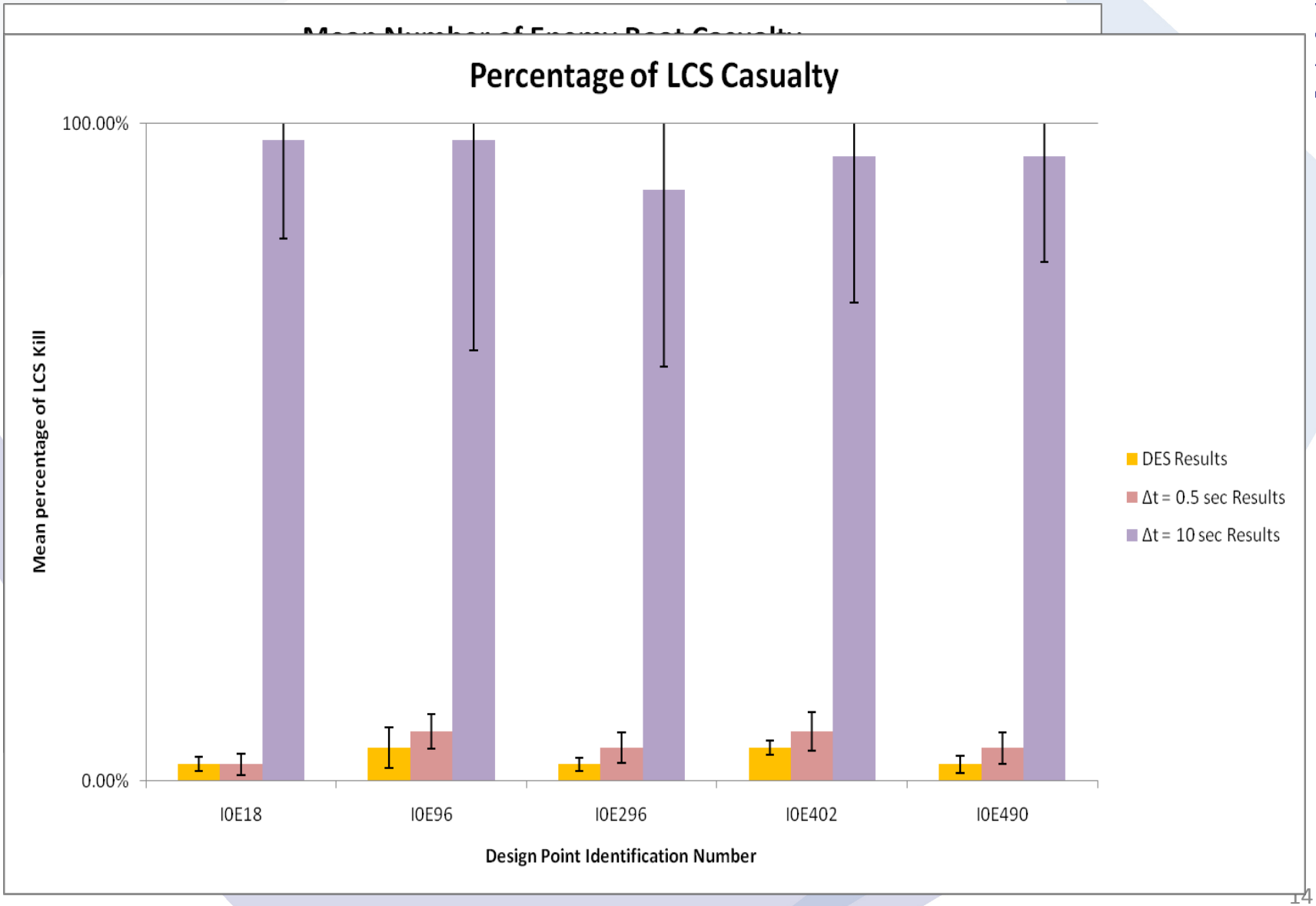
i. MANA 5 (DTS) environment with Δt = 0.5 and 10 seconds at 40 replications

ii. DAFS (DES) environment

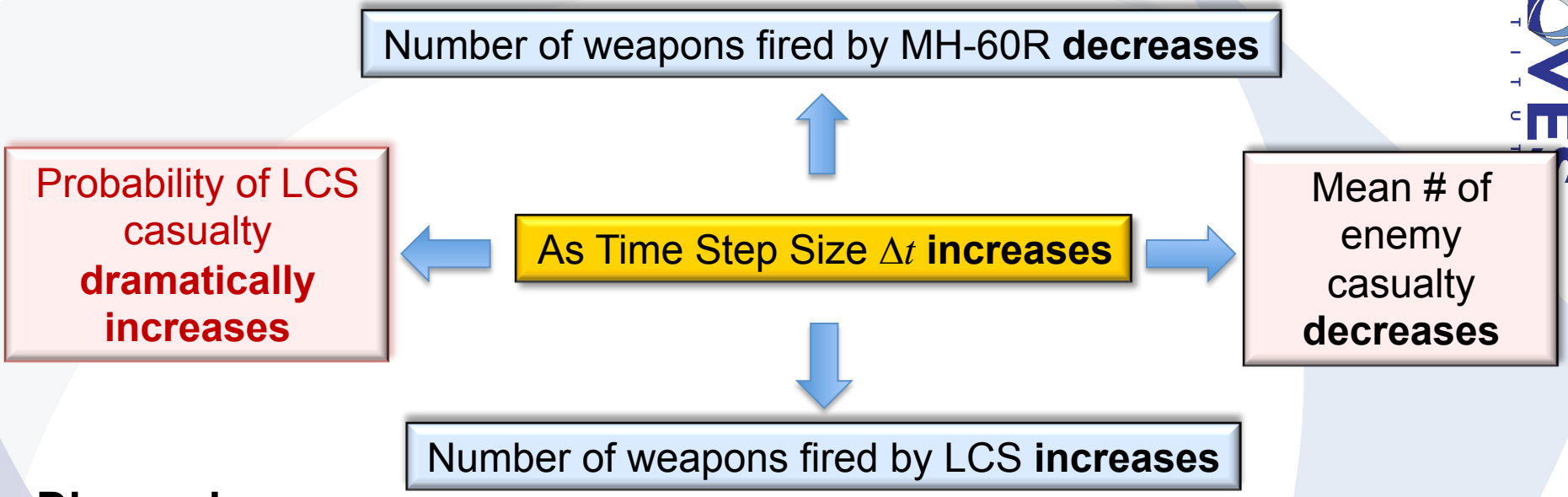


S 2: The LCS Battle

Results (cont….)



S 2: The LCS Battle



Discussions

- At large Δt large number of enemy boats were not detected and "skipped" MH-60 sensor range.
- State transition update allowed only at the end of time intervals,
  - ➢This introduces delays in rate of fire that leads to missing the enemy
- Difficult to notice these phenomena in complex/constructive simulations.
- **Recommendations**

Large Δt *(DTS)*	Firing rate, LCS capability/weapons
DES and small Δt *(DTS)*	Helicopter capability/weapons

Conclusions

- The choice of TAM impacts the simulation results.
- There are differences between approaches can leads to different results, outcomes and recommendations.
- The choice of Δt can also introduce significant qualitative anomalies.
- There is no accepted methodology in M&S for selecting Δt.
  - *Cannot separate time effects from system inherent properties*
- DES models tend to produce less (or no) anomalous behavior.

Questions?

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Back-up Slides

Typical Combat Simulation Environments

Discrete Time Simulation	Discrete Event Simulation
MANA	Simkit
Pythagoras	JDAFS – DAFS
IWARS	Combat XXI
ISAAC	NSS
PSOM	OneSAF
JCATS	
THUNDER	
VIC	
WARSIM	
EADSIM	
JICM	